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THESIS

AN ANALYSIS OF SERIAL NUMBER TRACKING AUTOMATIC IDENTIFICATION TECHNOLOGY AS USED IN NAVAL AVIATION PROGRAMS

by

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September 2002

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AN ANALSYS OF SERIAL NUMBER TRACKING AUTOMATIC IDENTIFICATION TECHNOLOGY USED IN NAVAL AVIATION PROGRAMS

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I. INTRODUCTION

A. PROBLEM

Hundreds of millions of dollars are being wasted each fiscal year on replacing repairable components that are lost in the Navy's logistics pipeline.

As the GAO reported (GAO 99-061, 1999) the Navy wrote off as "lost in-transit" over $3 billion dollars of resources between FY 1996 and FY 1998. Although the Navy disputes this figure (GAO 99-061, 1999; NAVSUP, 1998), it acknowledges that there are problems with its current method of tracking high cost components as they pass through logistics and repair centers.

B. SOLUTION TO THE PROBLEM

A possible solution to this problem is Naval Supply Systems Command (NAVSUP) and Naval Air Systems Command (NAVAIR) joint program named Serial Number Tracking (SNT). This project uses Automated Identification Technology (AIT) in the form of Contact Memory Buttons (CMB) and bar codes to improve the traceability of components. The Navy-wide implementation of this project could result in savings of nearly two-thirds of the $3 billion identified in the GAO report. Although this program is focused on aviation assets, funding of this project so it can be implemented Navy-wide is the key to achieving the two-thirds savings. Additionally SNT may also impact the long term configuration management of components. Data captured by the system, properly monitored and evaluated, could lead to the improved engineering of components, potentially improving readiness.

C. WHAT HAPPENS IF THIS PROBLEM IS NOT SOLVED

At an operational level, if the Navy remains unable to track its components through their life cycles and therefore continues to lose parts, funding for new systems and platforms will need to be diverted to cover these losses, thus slowing the development of new systems while also lowering the readiness of systems already deployed because of the delay experienced in acquiring replacement components.

Long term bleeding of Navy funds at a force level could make Congress wary of Navy budgetary requests. Congress then may place additional review measures on Navy financial planning procedures, thus slowing an already burdensome budgetary process. For the fleet this would increase the difficultly for Navy leaders to support their operating forces.

D. BACKGROUND

During FY 2002 the Navy sold, repaired or moved over 23 billion dollars in Aviation Components (i.e. repairables, Aviation Depot Level Repairables (AVDLRs)) to its supported organizations and units up until June 2002. (Executive Summary, 2002) Of that inventory, just over $8.9 billion required some form of tracking to locate the component because the current management systems could not find it without human intervention. (Supply in transit, 2002) $158 million dollars of these components were written off as ‘lost in-transit’ in FY 2001, while it was estimated that $130 million would be written off in FY 2002 (Inventory Loss, 2002). These numbers illustrate not only that there is a significant number of assets passing through the logistics system at any one time, but also that there is room for improved tracking of these components.

A method to improve the control over Navy assets can be found in the use of Information Technology (IT). Although IT usage has brought a wave of raw data to all levels of the Navy infrastructure, the collection and interpretation of that information threatens to overload logistics managers; ‘Making it difficult to see the forest, because of all the trees.’

The Navy is currently at work on several programs that use AIT systems to collect information from commercial and DoD sources, which can also assist in the management of assets. (Krizner, 2001)

One of these programs is SNT. This project, comprised of two elements; an Automated Information System (AIS) and Automatic Identification Technology (AIT) aims to accomplish the goal that has existed since the beginning of repairables management – tracking individual components through the supply, maintenance, and transportation logistics pipeline. (Hayes and Mullins, 2002; Commander NAVSUP, 2001) Initiated in November of 1998 in response to the Aviation Supply-Maintenance Readiness review, the system is a web-enabled Virtual Shared Data Warehouse (VSDW) that directly accesses multiple DoD maintenance and supply legacy databases. SNT will provide the fleet with total asset visibility (TAV) of marked components throughout the service life of the assets. (Hayes and Mullins, 2002)

A SNT prototype used a Contact Memory Button (CMB) AIT system attached to 206 components of aircraft belonging to

Helicopter Anti-submarine Squadron Light Forty (HSL-40) to track the maintenance frequency and logistics needs of selected avionics equipment and critical aviation components. This system has reportedly improved Integrated Logistics Support (ILS) of the SH-60 and increased the mission readiness of the weapon system. (Naval Air Warfare Center – Aircraft Division, 2000)

Even with the apparent success of the program (Hayes and Mullins, 2002; Commander NAVSUP, 2001) there are questions about the future usefulness of the program. Does it generate tangible savings for Navy? How is SNT information gathered? Is it an improvement over prior systems? Has SNT and AIT improved this process? Does the SNT system identify possible engineering problems or does it just report 'what it sees'? Do AIT programs improve the logistics life-cycle support of the aircraft or do they merely chase parts?

The priority for AIT and AIS implementation DoD wide has increased over the last ten years. AIT and Enterprise Resource Planning (ERP) systems once thought to be novelty items have become areas in which DoD financial managers believe present day funding can provide longtime payoffs for the services. (Krizner, 2001) By letting automated systems collect, analyze and provide management decision options, DoD may be able to reduce the amount of manpower and time involved with collecting and interpreting the data.

E. METHODOLOGY

Understanding the problems of fielding an AIT or AIS system requires a unique vocabulary. Appendix E provides a list of common acronyms used throughout these pages.

Chapter II explores the various AIT media available, and reviews their strengths and weaknesses. Chapter III provides additional insight into the need for and the development of SNT. It also expands upon the problems introduced in this chapter, and identifies cost-savings fields that will be analyzed in Chapter IV. Chapter IV presents cost-savings data and the results of the survey of program and item managers. Finally Chapter V provides our conclusions concerning the value of SNT and recommendations.

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II. AUTOMATIC IDENTIFICATION TECHNOLOGY

A. INTRODUCTION

Automatic Information Technology is a suite of technologies that enables the automatic capture of source date, thereby enhancing the ability to identify, track, document, and control; force deployment, equipment, personnel, and sustainment cargo. (Navy AIT, 2002) The following section discusses the seven types of AIT media that the DoD is currently using or prototyping. The media systems are detailed, with an overview of the technology's strengths and weaknesses.

B. AUTOMATIC DATA COLLECTION

Good decision-making is executed on the basis of feedback on events as they happen, not after they occur. It follows, then, that to achieve greater productivity, AIT systems must provide discipline and control upon the dynamics of actual operations. (Hill, 2002)

The primary benefits of AIT lay in improved data entry, increased data entry speed and enhanced ability in item identification. Even in ideal working conditions, a touch typist typically makes one mistake for every 30 entries. This error rate can increase when workers are operating under less than ideal conditions. (Krizner, 2001) Automatic identification systems operate in the accuracy range of one error in three million entries at higher processing rates than their human counterparts. (NAVSUP, 2000) In addition to the cost savings associated with increased speed and accuracy in automating data collection and data transfer, there are benefits resulting simply from item identification. (Air Force AIT, 2002) Verifying equipment and its condition that once may have taken hours due to lost or missing documentation, can now take only seconds.

C. BAR CODES

1. Background

Bar coding is the dominant AIT medium used by DoD and commercial industry. It consists of patterns of lines and white spaces of varying width that represent a group of characters. (Navy AIT, 2002) A typical bar code system consists of labels (bar codes), scanners, decoders and processors.

To use the data, the characters in a bar code are read by an optical scanner, which contains a source of light (usually a laser) that is aimed at the pattern of lines and spaces; the dark bars absorb the light, and the white spaces between the bars reflect the light. The resulting pattern of light and dark is measured by a decoder in the scanner, then translated into a binary code and transmitted to an AIS processor. (Bar Code Mechanics, 2002) Usually, bar codes are either printed onto an item during its manufacture or printed on to a label that is attached to the item following its delivery into the DoD logistics system.

Matching the growth of bar codes and printing/production alternatives has been the increasing sophistication of equipment to read, decode and use the encoded data. Bar code readers fall into two categories: hand-held and fixed position, automatic scanners.

Hand-held devices include contact wands or non-“light pens” that emit visible or infrared light and are manually scanned across the bar code. They are generally cable-linked to fixed or portable decoders that, in turn, store and transfer the validated data to a local computer or host for processing. It requires some manual dexterity on the part of the user to sweep the bar code so the wand can read them, but its basic design gives it an excellent cost to performance ratio. (Bar Code Standards, 2002) More sophisticated (and expensive) hand-held units include fixed and moving beam scanners using charge coupled device (CCD) technology, light emitting diodes (LED’s), or visible laser diodes (VLD). Depending upon the light source employed, bar code dimensions and quality, these devices can scan labels from distances of a few inches to several feet. (Bar Code Mechanics, 2002) This can benefit the user by granting greater flexibility in the reading process, removing the user from a hazardous area, or allowing the user to scan items that otherwise would require special equipment (e.g. scanning a box on top of a storage rack). (Krizner, 2001)

Fixed position scanners are mounted in a permanent location to automatically scan passing bar codes throughout a well-defined field of view. These scanners employ fixed-, moving-beam or raster laser, CCD or video camera technology to take from one to several hundred looks at the code as it passes. (Hill, 2002)

Processors can be any device, including the scanner itself, are capable of loading, storing and analyzing the data captured by a scanner.

Although most bar codes are similar in appearance, they are divided into subsections based on their symbology. Over 100 encodation schemes or symbologies have been invented since the technology was developed in 1933, but there are two basic categories of bar codes used in today's civilian and DoD applications; Linear and Two Dimensional (2D). (Krizner, 2001)

2. Linear Bar Codes

For the layman, linear bar codes are the oldest and presently the most common form of AIT media. The most familiar linear bar code is the Universal Product Code (UPC), first employed by the supermarket industry in 1973. Other common linear bar code symbologies are Code 39, pioneered by the defense and automotive industries; Codabar, used late in the 70's by blood banks, Interleaved 2-of-5 (ITF) commonly used by shipping agencies, and Code 128. (Bar Code Standards, 2002)

Linear bar codes can identify items and provide document control information for individual items or shipments. From foodstuffs in a grocery store to a national stock number (NSN) or transportation control number (TCN), they can be used to represent alphanumeric data elements that are used as an automated key to information positioned in an AIS database. Linear bar code technology is used in asset management, inventory, time and attendance administration, record keeping, document tracking, shipping/receiving, and piece part tracking. (Bar Code Mechanics, 2002)

a. Strengths

- Standardization – As a mature technology the standards have been well defined since their initial use in 1973. Current standards are promulgated and maintained by the international organization of Automatic Identification Manufactures (AIM).
- Low cost – Bar code systems can be purchased from sources throughout the world and are generally inexpensive.
- Accurate – Low rate of error.
- Easy to use – Minimal training requirement, simple interface and limited (or no) moving parts.
- Wide variety of system designs – From handheld to large stationary systems, there is a bar code system for nearly every application. (Bar Code Standards, 2002)

b. Weaknesses

- Bar codes can be damaged – Paper labels can be torn, washed out, or sun bleached so they are not readable. Metal labels can be lost or defaced.
- Environmental conditions – Harsh conditions may damage equipment.
- Security – Bar codes have no inherent security features. Anyone with a properly configured scanner and/or processor can read the data.

3. Two Dimensional (2D) Bar codes

2D bar codes are rapidly evolving and industry experts predict that they will replace the linear bar codes with in the next 10 years. (Bar Code Standards, 2002) 2D bar codes emerged during the late 1980's as a result of improvements in scanning technology. The basic rationale behind the development of 2D bar code symbologies was the need to increase the effective density of encoding, by either increasing the amount of data contained by a linear bar code, or by reducing the space needed by a 2D bar code to less than that required by an equivalent linear symbol. (Hill, 2002) 2D stacked symbology PDF-417 has the capability of encoding up to 2000 characters in four square inches, over ten times the amount of data held by a linear code (17 characters). (Bar Code Mechanics, 2002) 2D applications are those of linear codes but include the ability to process multi-packs, air pallets, and track repair items. (Navy AIT, 2002)

a. Strengths

- Multiple item usage – A single label can contain product descriptions, inventory information, price data, on an individual item or it can contain a bill of lading for multiple items.
- Can be encrypted – Data are not as susceptible to interception.
- Scanners can be used for linear codes also.
- Large data capacity
- Scanning is possible from any direction

b. Weaknesses

- Higher cost than linear system
- Standards not as widely accepted as linear code.

Figure 1. Data Matrix 2D Bar code

Figure 2. PDF 417 2D bar code

D. MAGNETIC STRIPE

Magnetic stripes have been used for years in bank and charge card transaction recording, commuter ticketing, time and attendance administration, and security access control. Automated Teller Machine (ATM) cards are one of the prominent uses of this technology, but to a lesser extent, the technology has been used for shop floor product control, failure analysis and work-in-process tracking. (Hill, 2002)

The magnetic stripe media is composed of magnetic bars twenty millionths of an inch long. (Magnetic Stripe Data, 2002) The magnets are mixed with a binding agent that is then affixed or ‘painted’ on to an item, most commonly a plastic card. Prior to drying, the magnetic particles are polarized so they can then be encoded. A single magnetic stripe contains three low-density tracks for data. Tracks one and three can store up to 210 bits per inch (bpi), while track two can store 70 bpi. Combined, the tracks can store a much higher quantity of information than bar codes. (Magnetic Stripe Data, 2002)

Reading data from a magnetic stripe card is done by way of swipe/insert readers. The magnetic stripe must come in contact with the reader and the magnetic stripes must be relatively undamaged.

1. Strengths

- Worldwide industry standard – Any machine conforming to the standard can read Magnetic Stripe cards made by a manufacture.
- Inexpensive – The manufacturing process and investment capital to produce magnetic stripe cards is fairly low cost. The magnetic stripe can be placed on to nearly any non-conducting surface, normally paper or plastic.
- Durable – A magnetic stripe on a plastic card can endure in a harsh environment and still give accurate readings
- Reuse – Encoded information can be erased and the card can be recoded with new data.

2. Weaknesses

- Magnetic media – Magnetic stripes are susceptible to strong electromagnetic fields, which can scramble or erase encoded information.

- Contact – The media requires that the magnetic stripe contact the reader, although excellent for personal or security uses it limits the flexibility of the media.

- Duplication – Because of the inexpensive cost to produce, stripe cards are often the targets of illegal duplication. (Raman, 2002)

- Proper alignment – The reader and magnetic stripe card must be aligned during the reading process. If through damage or environmental conditions they cannot align, data may not be recoverable. (Magnetic Stripe Data, 2002)

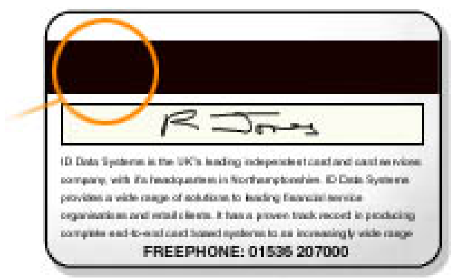

Figure 3. Magnetic Stripe

E. SMART CARDS

Integrated Circuit Cards or Smart Cards are devices the size and shape of a credit card that contain an integrated circuit chip (ICC) allowing it to process as well as store information. (Navy AIT, 2002) There are several terms used to identify cards with integrated circuits embedded in them. The terms "chip card," "integrated circuit card", and "smart card" all refer to the same thing. (Smart Card Data, 2002)

These cards combine several of the AIT technologies into one media device. Smart cards can have a microprocessor which can read, write, calculate and store data in memory embedded into the card, a magnetic stripe, a 2D bar code, digitized photo and printed information. (Smart Card Data, 2002)

There are two types of smart card. The first is really a "dumb" card in that it only contains memory. These cards are used to store information but not process, i.e. might include stored value cards where the memory stores a dollar value, which the user can spend in a variety of transactions (e.g. Phone cards). (Dixon, 2001)

The second type of card is a true "smart" card where a microprocessor is embedded in the card along with memory. The card actually has the ability to make decisions about the data stored on the card. The card is not dependent on AIS to make the application work. (Navy AIT, 2002)

The Department of Defense is implementing smart card technology as its identification card for active duty uniformed services personnel, members of the Selected Reserve, DoD civilian employees, and eligible contractors. The new ID card is called the Common Access Card or CAC.

One of the largest smart card implementations to date in the United States, CAC is an advanced smart card with a 32K Java(TM) Virtual Machine and cryptologic co-processor ICC. (Dixon, 2001)

1. Strengths

- Read/write and processing technology – Cards can accept, store and allow retrieval of information. Data can be added to a card, without affecting stored data.

- Contact or close proximity (contactless cards) read capability – The cards are flexible and can be used in either manner.
- Reasonability high storage capacity – Use of multiple media along with the storage capacity of the microprocessor grants a significant amount of memory.
- Strong security features – Combination of media types and microprocessor provides protection against fraudulent use that surpasses traditionally encoded media.
- Low cost cards and readers – As the technology grows and a larger number of industries turn to smart cards, the price decreases due a greater number of manufactures entering the market. (Smart Card Data, 2002; Dixon, 2001)

2. Weaknesses

- Electromagnetic/environmental vulnerability – Although more durable than independent media types, smart cards can still be aversely effected.
- Limited enthusiasm – Although DoD is beginning to replace identification card with CACs, commercial usage of smart cards in the United States lags behind Europe. (Smart Card Data, 2002; Dixon, 2001)

Figure 4. Smart Card with Magnetic Stripe and ICC

F. OPTICAL MEMORY CARDS

Optical Memory Cards (OMCs), also known as Laser Cards, use technology similar to that used for music CDs or recordable CD ROMs. Data can be ‘written’ to the card in increments rather than all at one time, an OMC can have data written to it in a sequential order on many occasions until all available memory has been used, thus extending the life of the card. Similar to ‘burning’ CDs, a laser is used to ‘burn’ the information on to the card, while a low power laser is used to read the material off the card. (Optical Memory Card, 2002)

This credit card sized medium can be attached to a piece of equipment (e.g. maintenance records) or given to a person (e.g. medical records) to provide complete historical data, or they can be included in the transfer of a large shipment to facilitate receipt processing.

OMCs are regularly used by the Army to transfer depot supply and transportation data to supply support activities. (Optical Memory Card, 2002)

1. Strengths

- Large storage capacity - optical card can currently store between 4 and 6.6 MB of data which gives the ability to store graphical images such as photographs, logos, fingerprints, x-rays (Optical Memory Card, 2002)
- Non-erasable – High durability that can withstand harsh treatment and environmental extremes. Also provides users a permanent audit trail.
- Updateable – Information can be read and/or updated by any user with proper equipment.
- Counterfeit Resistance - Embedded Holograms, biometric identifiers, thermal color printing, data encryption, serial number encoding and additional security features. (Laser Card, 2002)

2. Weaknesses

- High unit cost – Although a package set consisting of 30 OMCs, a reader, and writer can be purchased for less than Fifteen Hundred dollars, OMC cards in comparison against bar codes or magnetic stripe media are usually five to ten times the cost. (Laser Card, 2002)
- Limited storage size – Although OMC storage size is significant, once the card is full no more data can be added to the card.

Figure 5. Optical Memory Card used by DLA

G. RADIO FREQUENCY IDENTIFICATION

Radio Frequency Identification (RFID) is a relatively new approach to automatically identify assets within a range of a few inches to 300 feet. The technology allows a user to locate, identify the contents of and if needed, redirect individual containers. (Navy AIT, 2002)

A typical RFID system will consist of a reader (or interrogator), a tag and an AIS to process the data read from the tag. (Neckel, 1998)

The complexity of a reader can vary considerably, depending on the type of tag used and the function to be fulfilled. Basically a reader has radio circuitry to communicate with a tag, a microprocessor (to check and decode the data), memory (to store data) and an antenna/s (depending on the frequency), which may or may not be enclosed in it. (Roberti, 2002)

RFID reader frequencies can be classified from low to high, and have a direct effect on the range of the reader and any requirement for a direct line of sight (LOS) to read a tag. Also as the frequencies increase the hazards to humans increase, thus some HF systems require special licensing and may have usage restrictions.

Type	Frequency	Range	LOS Req	License Req
Low (LF)	Below 500kHz	1-3 m	No	No
Medium (MF)	500kHz - 15Mz	5-15 m	No	No
High (HF)	850 – 950MHz	10-300 m	Yes	Yes
Ultra High (UHF)	2.4-5.8 GHz	30 m +	Yes	Yes

Table 1. RFID Comparison

Reading ranges vary not only with a systems frequency, but also what type of tag is being used, the size of the tag, material between the tag and the reader, electromagnetic interference. (Draft Paper, 2000)

There are two types of RFID technology - passive and active. DoD has focused its RFID efforts on the active technology because of the system's greater range and storage capacity. Review of commercial passive RFID programs has led DoD to conclude that passive RFID uses are not feasible in the DoD environment. (Navy AIT, 2002)

Active RF tags can contain information that ranges from a permanent ID number programmed into the tag by the manufacturer to a variable 1MB memory that can be programmed by an interrogator (reader) using RF energy. (Draft Paper, 2000)

System operations with active tags are simple; the interrogator sends an RF signal that "wakes up" the tag, and the tag transmits information to the interrogator. Additionally the interrogator can write new information on the tag. (Draft Paper, 2000))

RFID tags come in a wide variety of shapes and sizes. Passive tags used as animal tracking devices, inserted beneath the skin, can be as small as a pencil lead in diameter and one-half inch in length. Tags can be screw-shaped to identify trees or wooden items, or credit card shaped for use in access applications. An example would be the small anti-theft hard plastic tags attached to merchandise in stores. Active tags such as the heavy-duty five by four by two-inch rectangular transponders are used to track intermodal containers, heavy machinery, trucks, and railroad cars.

An internal battery powers active tags, which are typically read/write devices. The use of a battery means that a sealed active transponder has a finite lifetime. However, a high endurance battery cell coupled to suitable low power circuitry can last for ten or more years, depending upon the operating temperatures, read/write cycles and usage. The trade-off is greater size and greater cost compared with passive tags. Passive tags receive energy to operate from their interrogators, but have a lower capacity to store information. (RFID, 2002)

The object of any RFID system is to carry data and to then retrieve that data, when needed. Data within a tag may provide identification for: an item in manufacture, goods in transit, a shipping location, contents of a shipping container, the identity of a vehicle, an animal or individual. (RFID, 2002)

DoD believes RFID is the first step on the road to total asset visibility (TAV) over supplies and equipment moving through its transportation pipeline. (Gonzales, 2002; Navy AIT, 2002) TAV begins when the RFID tag is populated with supply and transportation documentation data from a distribution depot's AIS and the tag's data is sent to a regional in-transit visibility server (RITV). Once information is loaded into the RITV, the tag is placed on the shipping container. This gives the user the capability to stand-off; In the box, or, in other words, know the Transportation Control Numbers (TCN), NSN, quantity, receiving unit and description of every item in the shipping container by the information coded in the tag. The RFID system integrated with a RITV server, linked to the Global Transportation Network (GTN) and Joint Total Asset Visibility (JTAL) program, can provide 24/7 asset visibility of in-transit materials. (Gonzales, 2002; Navy AIT, 2002)

DoD first used active RFID technology during the ocean retrograde of munitions and equipment from European Cold War stocks in 1992. According to a September 1992 GAO report, $2.7 billion worth of spare parts went unused during Operation Desert Storm. Based on the European retrograde, the Army estimated that if an effective method of tracking the location and content of cargo containers had existed (RFID), DOD could have saved approximately $2 billion. (Gonzales, 2002)

1. Strengths

- Automated system – Does not require human interaction to initiate scans.
- HF RFID does not require LOS – Unlike bar codes or OMC, users can ‘stand-off’ and gather data from long distances. (RFID, 2002)

- Omni directional reading – Tags can be placed nearly anywhere on a container or item and it does not interfere or hinder data transfer. (RFID, 2002)
- Can be programmed to respond to environmental conditions – RFID can be configured as security locks on cargo containers or environmental reporting devices (high temperature monitoring). (Roberti, 2002)
- Allows Global tracking – RFID coupled with a Global Positioning System (GPS) and the proper software package can provide users complete ITV. (Gonzales, 2002)
- Low Cost – Passive tags used by retailers cost as low as two cents each. Active tags, once the largest significant reoccurring expense of a RFID system, are constantly being reengineered. Technology advancements in recent years have created a 'paper RFID' tag. Using the process, engineers say they can now drive the cost of an RFID tag to less than 30 cents apiece, and maybe as low as 10 cents each. As a result, they expect to push RFID technology into low-cost, disposable packaging, which has not been considered feasible up to now. (Paper Transponder, 2001)
- Smart tags – The merging of ICCs with RFID have developed tags that can do more than just store data. They can maintain a perpetual inventory, identify non-compatible items in a shipping

container, and generate an alarm if removed from a location. The uses continue to grow. (RFID, 2002)

2. Weaknesses

- RFID can be jammed – As with any radio, RFID can be electronically jammed.
- HF RFID – Due to the hazards to humans and special materials (e.g. ammunition, fuels, and certain types of electronic equipment), certain frequencies are limited or prohibited by various countries. In some areas special licenses are required to operate RFID systems.
- Standards – The growth of RFID, both in its technology and the number of manufactures producing RFID equipment, has increased the problems associated with attaining one standard. (RFID, 2002)

RFID, first used in 1969 to minimize book theft in libraries (RFID Timeline, 2002), is one of the areas that DoD believes it will benefit most.

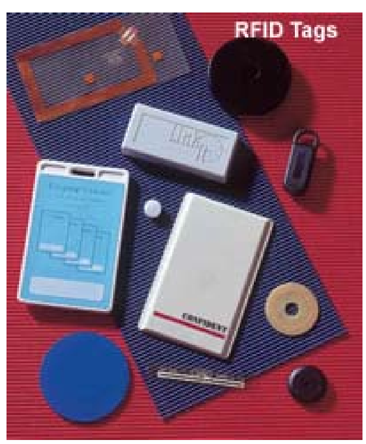

Figure 6. Examples of RFID Tag Types

Figure 7. Examples of RFID Readers

H. RADIO FREQUENCY DATA COLLECTION

Radio Frequency Data Collection (RFDC) is not a unique technology; it is merger of Bar code and RFID technologies. RFDC is used to communicate information, usually in a warehouse setting, from mobile locations to a host computer in real time. Where RFID's purpose is to track materials, RFDC's purpose is to manage inventories through the use of RF terminals.

There are three basic components of a RFDC system: portable hand held (or vehicle mounted) units with bar code scanners, keyboards and multi-line displays; base station(s) providing the radio link between the portable units; A computer controller (AIS) handling the communication's traffic between the radios and the computer.

Linked to the terminals by the wireless portable units, material handlers are instructed by the AIS where to store material in order to maximize warehouse space or picking efficiency. Bar coded location codes are scanned as the material is stored, and if desired a manual inventory can be conducted and entered into the AIS from the location. During the pick phase of warehouse operations, the AIS direct the material handlers to pick locations using a most efficient route program to minimize worker transit time. (Navy AIT, 2002)

The strengths and weaknesses are the same as those associated with RFID and bar codes.

I. BIOMETRICS

Biometrics refers to automatic identification of a person based on his or her physiological characteristics. These characteristics include retinal scans, fingerprints, hand geometry, facial features or voice recognition. Most of these technologies are geared toward the proper identification of personnel; some, like fingerprints, have been combined with other technologies. For example, the CAC smart card issued to service members is encoded with a biometric fingerprint of the cardholder. (Jain, Hong and Pankanti, 2000)

Biometric technology, by and large, has limited potential for military logistics in areas other than personal security. With that said, voice recognition programs have been used to reduce manual computer input workload, but the technology itself is only assisting another AIT systems. (Biometrics, 2002)

1. Strengths

- Security – Overall security is improved. Unauthorized persons cannot access information, receive material, or enter areas that are secured.

- Personal Security – Positively identifies an individual.
- Saves time – Voice recognition technology can reduce data input times.

2. Weaknesses

- "Lost identities" – Lost card could be a nuisance or security problem.
- High cost – The technology is improving and becoming easier to use and procure, but system cost is still relatively high. (Koller, 2001)

J. CONTACT MEMORY

Contact Memory uses technology similar to that found in RFID transponder tags, often considered a low-cost cousin of the RFID tag. Contact memory tags, typically designed as buttons and called Contact Memory Buttons (CMBs,) are small electronic identification and data storage devices. CMBs can be as small as a dime, a few times thicker, and hold up to 32 kilobytes of data. They can be thought of as small computer diskettes capable of storing any type of digital data including text, photographs, graphics and sounds. (Navy AIT, 2002)

CMBs are designed for permanent attachment to objects such as heavy machinery, equipment, animals, pallets, to identify and retain information specific to those objects. The CMB serves as a remote database which allows important data to be available on demand, without the necessity of referencing a central database which may be impractical or uneconomical in a field location.

These data files are accessed, edited or appended with a simple probe that makes contact with the CMB. The probe transfers the data from CMB to a portable data collection terminal, laptop or AIS. (Contact Memory Buttons, 2002) Depending on what needs to be done, the user can manipulate the data and then download it back into the CMB by way of the probe.

Some buttons are powered by small internal batteries that guarantee data retention for 10 years from their date of manufacture. This ensures that data will not be lost due to lack of charge.

Other battery-free designs can retain data up to 100 years, because each time the button is read, a small amount of additional power is transmitted to it through the probe, extending its charge. There is a risk of data loss if the CMB is not accessed from time to time to allow for a new charge. (Contact Memory Buttons, 2002)

Though more expensive than barcode labels, CMBs are designed to withstand harsh environments including temperature extremes (-55C to +100C), static, electromagnetic fields, radiation, mechanical stress, weather extremes and corrosive atmospheres. (Contact Memory, 1999)

CMBs tags are used in a number of applications. Security companies and delivery companies use contact memory to manage their routes. Tradeshow companies use contact memory to facilitate registration and track attendee interests. (Contact Memory, 1999) NASA uses contact memory buttons in its Space Shuttle Program inspection system. Ford Motor Company uses them in the manufacturing of truck engines. Boeing Aerospace uses CMBs to track motors from cradle to grave, recording and maintaining inventory and maintenance management information on each motor. (Krizner, 2000) Other applications include mail/cargo bins, asset maintenance management programs, payroll/piecework tracking, hazardous waste management and animal tracking. (Contact Memory, 1999)

Some DoD specific uses include tracking of aircraft components on various airframes, use as maintenance logs, guard tour tracking, and paperless logbooks for guided missiles. (O'Brian, 1998)

1. Strengths

- Read/write, electronic storage technology – CMB systems allows users to review, modify, and save information about the component the CMB is attached to by contact with a compatible probe and AIS system.
- Low to relatively high data storage capability – CMBs memory range from 128 bytes to four million bytes of compressed information. The industry standard presently is a 32kb button. (O'Brian, 1998)
- Relatively low cost tags, programming and read facilities – The cost for buttons has steadily decreased, for the common 32 kilobyte CMBs costs (depending on the system) can be as low as five dollars. (O'Brian, 1998) Probes, programming, and reading systems vary in cost; a complete AIS

inventory and maintenance system may run into millions, while a small system formed around a Laptop may involve only two thousand dollars to start up. Cost for any CMB system can be based on the usage needs, interface operating system and durability of the system in light of environmental requirements. (Contact Memory Buttons, 2002)

- Data transfer rate determined by systems and serial interface – Maximum transfer rate is currently 16kb per second (kps).
- CMBs are suitable for harsh environments – CMBs can endure temperature extremes of; –55C^{O} to + 100C^{O}, radiation (X-ray, Gamma, and ultra violet) up to 100,000 rads, electro magnetic pulse -5.8, 26.7 and 55kV/m, shear strength up to 3,026 lbs., and tension strength up to 4,000 lbs. PSI.
- Interchangeable with barcode and other AIT systems – Bar code and RFID information can be processed by CMB AIT systems by just changing the probe to either a RFID or bar code scanner. Data from RFID and bar code tagged items can be scanned into AIS, which can then download the data into a CMB. (Wetzig, 2000)
- Stand-alone data file – CMBs are independent memory locations. Although readers and AIS are needed to process the information stored on a CMB, external connections, wire, or equipment are not required to maintain a CMB itself.

2. Weaknesses

- Limited application base – CMBs are versatile, but they lend themselves to storage of between 32kb and 4MB of data. CMBs rewritabliltiy and storage capacity are often unnecessary extras for simple data collection activities. (Navy AIT, 2002)
- Cost of systems relative to other AIT – Bar codes and some RFID systems have a lower cost per unit than the majority of contact memory systems.
- Requires contact to transfer data – The present technology requires that the probe contact the CMB to transfer data. This requires the CMB be on an accessible portion of the component where it may be damaged. Additionally personnel accessing the CMB, depending on the environment the CMB is located in, may be placed at risk.

Figure 9 is a pictorial display of various button sizes. Figure 10 gives a pictorial comparison between a mega CMB and a dime.

Figure 8. Contact Memory Buttons

Figure 9. A CMB comparison

K. MEDIA COMPARISON

A brief comparison of the AIT mediums is presented in Appendix A.

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III. SERIAL NUMBER TRACKING

A. INTRODUCTION

The Serial Number Tracking (SNT) program is a complex technological and management tool. This chapter presents the SNT program, its issues and its potential benefits.

B. BACKGROUND

1. Commercial SNT

Much can be learned from industry practices of incorporating the latest technology into logistical processes. One of the programs the Navy has been watching is the SNT system used by aircraft manufactures (e.g. Boeing), airlines (e.g. American Airlines), and air transport organizations (e.g. Air Transportation Association (ATA)). (Krizner, 2000; Anonymous, 2000)

Boeing's use of bar code technology for serial number tracking dates back to 1993 when they first used the technology to track component items for their 777 airliners. (Krizner, 2000; O'Brian 1998) The large number of contractors for that aircraft necessitated an improved manner of tracking incoming components, and became the forerunner SNT program for the industry. Even as other companies and organizations adopted Boeing's system, Boeing began using CMBs to replace the older bar codes.

For the commercial aircraft/airline industry the SNT program, combined with AIT, has helped to reduce unit cost, repair cycle time and system defects through the tracking of components. One of the key areas in which commercial SNT systems have benefited the airlines is in the early identification of 'rouge' parts. Rogue parts have an indication of failure, are removed and replaced, yet retest okay (Navy calls them ‘No-fault Parts’). ATA-member airlines believe that rogue parts issues alone cost them more than $100 million a year in lost revenues. (Krizner, 2000)

2. Importance of a SNT system

The Naval Aviation is faced with problems of its own. A 1999 GAO report noted that between Fiscal Years (FY) 1996 and 1998, the Navy wrote off as ‘lost in-transit’ inventory valued at over $3 billion. (GAO 99-61, 1999) Another GAO report stated that between 1994 and 1999 prices for all Navy-managed parts have increased at an average annual rate of 12 percent, however prices for parts with high sales volume, (i.e. aviation and electronics items) increased at an average annual rate of 27 percent. (GAO 00-23, 2000)

An example of how pronounced these cost increases are can be found in a report of the Defense Logistics Agency’s (DLA) lead supply center for aviation. Between FY 1996 and FY 2000 it reported that the dollar value of annual sales increased about 54 percent, even though the center sold 28 percent fewer spare parts. Simply put, the total number of parts purchased went down, but the cost to Navy for these components went up, making the tracking of parts even more critical from a financial standpoint. (GAO 02-452, 2002)

With over 70,000 types of aviation reparable parts, (GAO 00-23, 2000; Executive Summary, 2002) the volume and variety of components, parts and storage locations has caused many problems within the DoD logistics pipeline. Missing inventory, No-fault parts (‘rouge’), Ready for Issue (RFI) and non-RFI (NRFI) component intermixing, overaged items in storage, and Schedule Removal Component (SRC) card losses are a few of the issues that influence the availably of aviation logistics support. (NAVAIR NAMP, 2002)

Although studies, ranging from GAO reports (GAO 96-156, 1996) to unit level surveys (Supply In-transit, 2002), have identified the problems in the Navy's method of handling and tracking aircraft components, they have fallen short on developing a comprehensive solution.

3. Navy SNT

SNT may help reduce these problems. Research on a SNT program tailored for Navy uses began with SABRE Group Inc. (defense contractor) being tasked to gather information on aviation support legacy systems and provide a Proof of Concept (POC) recommendation for a Navy SNT system. (SABRE Group, 1999)

Although the Navy has several older systems that perform tracking functions, there is no overarching system that combines their information to provide a complete asset picture. Of the systems SABRE reviewed, the three following systems were determined to contain the most useful data and operational elements for a SNT system; Navy Aviation Maintenance System, Optimized Organizational Maintenance Activities (NALCOMIS (OOMA)); Advanced Traceability and Control (ATAC), and Manufacturing Resource Planning II (MRPII). (SABRE Group, 1999)

SABRE also evaluated several Commercial Off-The-Shelf (COTS) products, but the commercial systems available were deemed too expensive and slow to implement. (Hayes and Mullins, 2002)

In September of 1999, based on the POC, a SNT Concept of Operations (CONOPS) was developed and submitted to NAVSUP. The CONCOPS provided NAVSUP with an implementation plan for SNT, a description of the operational elements of the program, and a review of the interface between data collection (AIT) and SNT users. It also recommended the prototyping of CMBs on H-60 aircraft in HSL-40. (Hayes, 1999)

Later in September a 'Business Case Analysis (BCA) of Serial Number Tracking', generated by the FOSSAC Price Fighter$ Department was delivered to NAVSUP. This BCA described the estimated program savings that SNT implementation would have on Naval Aviation platforms. (FOSSAC, 1999)

The SNT prototype identified in the CONOPS began in the spring of 2000. 25 line items (e.g. 206 components) were selected based on the Navy's Aviation Maintenance/Supply Review top degrader list and local inputs from HSLWINGLANT. After a short hands-on training session for squadron personnel, the components were marked with CMB's and bar codes, thus allowing the interested organizations to evaluate both AIT media systems. (Naval Air Warfare Center, 2000)

4. The Future of SNT

The development of SNT has continued throughout the prototype phase. As a Navy wide Enterprise Resource Planning (ERP) system slowly becomes a reality, SNT will be integrated into an ERP solution through the use of the Systems Application Processes (SAP AG) ERP product. (Mullins, 2002; What is SAP, 2002)

An ERP solution integrates functionality needs into a single program. It replaces the legacy stand-alone computer systems with a single unified software program divided into software modules that are similar to the old stand-alone systems. Activities such as accounting, repair and logistics still get their own software, except that now the software is linked together so that someone in budgeting can view logistics data to see if material is on hand, on order or in transit. (Koch, 2002)

NAVAIR has named their ERP system SIGMA, and is presently testing it with the E-2C Hawkeye program. At an organizational level, NAVAIR is planning to deploy SIGMA within the next five years. (Program Management Pilot, 2002)

An important side note is that several of the systems that provide information to SNT will either be upgraded or replaced within the next 10 years. A prime example of this is the introduction of the Supply Maintenance Aviation Reengineering Team (SMART) program. SMART, an ERP system, is to replace the Navy's legacy wholesale (UICP) and stock point (U2) supply systems; two subsystems that feed the SNT database. (Aviation Supply Chain, 2002)

C. SNT PURPOSE, OPERATIONS, AND AIT INTERFACE

1. Purpose

SNT's goal is to provide the Navy Total Asset Visibility (TAV) of serialized components through the integration of two systems:

- A computerized AIS that can monitor, report status on, and consolidate data concerning marked components

- An automated identification method that allows quick data entry and retrieval, and eliminates manual entry of data as much as possible (FOSSAC, 1999)

The combination of these two elements will provide SNT users with the benefits of:

- Supporting performance based logistics
- Assess depot performance
- Track usage history
- Target items for disposal
- Track reliability
- Isolate ILS deficiencies to specific organizations
- Aid in configuration management
- Determine part usage
- Aid in ‘Fleet Screens’
- Provide ‘real time in-transit visibility’ of components, especially high cost aviation depot level repairables (AVDLR) (Hayes and Mullins, 2002; FOSSAC, 1999; Hayes, 1999)

2. Operations

SNT is a “closed-loop” cradle-to-grave tracking system of maintenance-critical, serialized components, providing asset and material status, and enabled by AIT. (Hayes and Mullins, 2002)

Most components currently in the Navy’s inventory have serial numbers assigned as part of their nameplate data. SNT will track the serial number and provide the ability to cross-reference that information to other maintenance and supply data elements, such as NSNs, part numbers, document numbers, and job control numbers. (Hayes, 1999)

a. Procedures

The basic process of SNT follows these steps:

- Components identified – Nameplate data, SRC Cards, contractor data, and warranty information is used to correctly identify components. This is done either upon/prior to delivery to DoD or while the component is in the logistics pipeline (e.g. installed, storage, in repair) (Hayes and Mullins, 2002)

- Components labeled - Once identified a CMB (bar codes and CMB were used in the prototype period, but CMBs were recommended as the AIT medium of choice) is affixed to the component using NAVAIR approved procedures. (Naval Aviation Systems Team, 2002)

- CMB is populated with data – Once affixed to the component a technician/maintenance person using a CMB probe and portable data collection device downloads component information to the CMB.

- Data transfer – Data upload and download of part information for inventory, maintenance, validation, storage and tracking purposes.

- Component maintenance data transfer – If a component requires repair, parts used to repair the component can be entered into the SNT database and then downloaded to the CMB as a record of the event. If the component requires removal, SNT using NALCOMIS

OOMA can be used to identify the recently removed and newly installed components. (Hayes, 1999)

- Component repair tracking – As a component proceeds through the repair cycle, ATAC hubs and Nodes control points identify the location of the component and report the information to the SNT database. (Hayes and Mullins, 2002)
- Return to RFI condition – As components are repaired, the MRPII database reports its readiness condition and position for issue.

Figure 3-1 illustrates the SNT cycle. Nine DoD information systems feed SNT information (commercial system input depends on certain conditions; repair location, supporting organization, and transportation method). Of these only three provide SNT with information specific to Naval Aviation assets.

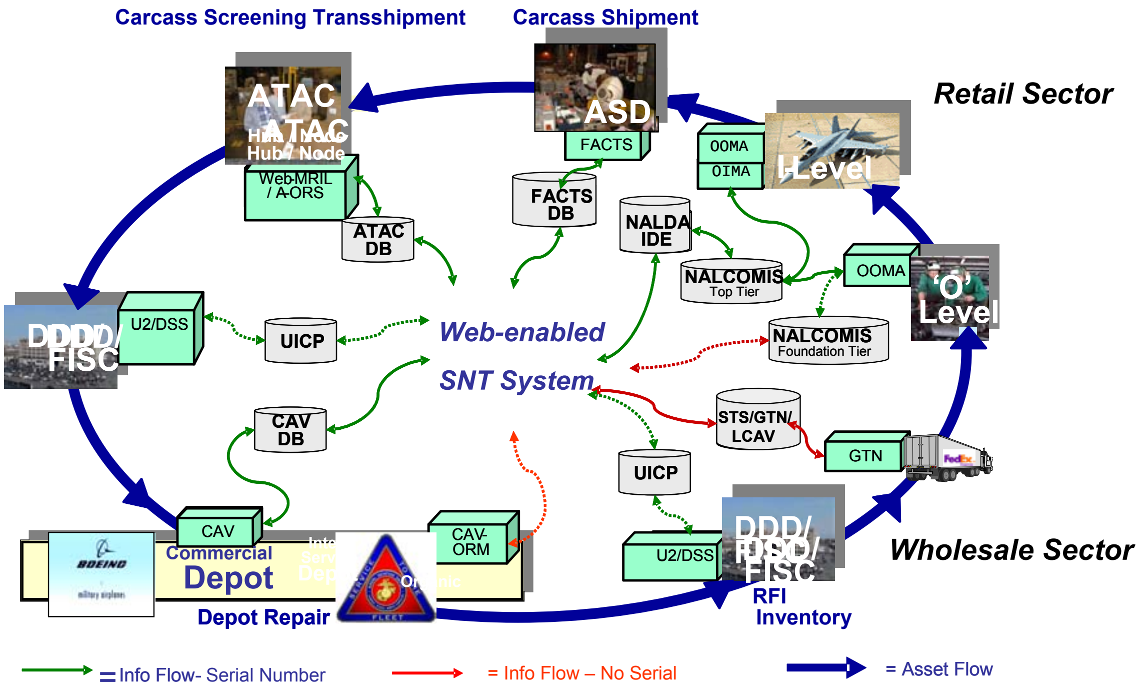

Figure 10. SNT information system

b. *Data Collection, Storage, and Transfer*

Presently SNT CMB memory files contain the following mandatory data elements:

- Vendor part numbers
- Vendor serial numbers
- Commercial And Government Entity (CAGE) codes
- Manufacture dates
- Lot numbers
- Nomenclature
- Model numbers

Additionally, depending on the component or part, a CMB memory file also may contain:

- NSN
- DoDIC
- DD250 data
- HAZMAT Codes
- Shelf life data
- Warranty information
- Contract number
- SMIC and DeMil codes
- Equipment Maintenance records. (Hayes and Mullins, 2002; SABRE Group, 1999; Hayes, 1999)

Data transfer between SNT and the supporting databases is conducted via a Virtual Shared Data Warehouse which uses a combination of replicated data (databases that are automatically copied and sent electronically to SNT) and direct access queries. This is essential because the key process improvement of SNT is its capability to receive quality data directly from source systems, thus avoiding data backlogs. (Hayes, 1999)

3. SNT AIT

AIT is the backbone of SNT. Without the accurate and quick transfer of information from operating units and repair depots to logistics managers, SNT would be just another data processing AIS. (FOSSAC, 1999)

CMBs are the prime technology associated with the Naval Aviation SNT program. NAVAIR has determined that the benefits of large data storage, capability for encryption, ability to partition data cells, and its high survivability make it a better choice than the continued use of bar codes. (Hayes and Mullins, 2002)

D. SNT ANALYSIS AREAS

SNT’s goal is to track individual aircraft components through the repair, storage, and transportation cycles of the logistics pipeline. If this task is completed in a quick and efficient manner, Naval aviation maintenance will be better able to fulfill its mission of maximizing aircraft readiness. (Hayes and Mullins, 2002; Program Management Pilot, 2002)

There are four discussion categories that concern the financial and operational benefits of SNT:

- Reduction in material loss
- Reduction in administrative costs (e.g. lost documentation)
- Reconciliation of material receipts
- Manpower cost savings associated with AIT.

1. Reduction in Material Loss

As mentioned earlier, the Navy lost over three billion dollars of in-transit material. (GAO 99-61, 1999) Additional research showed that of the Navy’s 21 million requisition transactions, over 60 percent had errors in their receipt and accounting procedures. (GAO 99-61, 1999; Hilton, 1999)

In a study conducted by NAVSUP to reconcile this loss, research showed that of 673 items surveyed (with a value of

107 million dollars) 23 percent of the items were unable to be accounted for and considered lost-in-shipment. Of the remaining 77 percent; 49 percent was accounted for, 23 percent had no records, and the last five percent were considered partial receipts and had a secondary requisition generated for the original requisition. (FOSSAC, 1999)

One of SNT's goals is to provide in-transit visibility of components as they progress through the logistics pipeline. Once SNT is fully implemented, the Navy believes that it could nearly eliminate the 23 percent of its lost materiel problems and the costs associated with them. (Hayes and Mullins, 2002)

This is considered a major savings since NAVSUP's annual loss 'in transit write off' in FY2000 for aviation repairables was $296 million, $181 million in FY2001 and was projected to be $130 million for FY2002. (Loss in transit, 2002)

2. Reduction in Administrative Costs

The Scheduled Removal Component (SRC) card is a two-page form used to record maintenance history, installation, and usage data. When the component is removed from the aircraft or equipment, the SRC card accompanies the component. (OPNAVINST 4790.2H, 2002) Loss of an SRC card can cause the loss of the assembly as an RFI asset, due to the uncertainty of the asset's status. Since failure of a component may have catastrophic consequences, it is mandatory that documented proof of its service life be determined prior to installation. (OPNAVINST 4790.2H, 2002)

Costs associated with the loss of a SRC card include (but are not limited to):

- Man-hours needed to identify and trace the component
- Potential aircraft mission down time
- The replacement of components if recertification can not be accomplished. (Executive Summary, 2002)

The evaluation of SRC savings was based upon a NAVAIR SRC loss (Negative Reconstruction) data reports for FY 2000, 2001 and 2002 (thru July). These reports identify replacement component cost data for SRC card loss. (Mathis, 2002)

Reduction of SRC card loss is one of the key quantifiable areas of administrative savings; other areas exist but these benefits will be evaluated under the cost savings associated with AIT.

3. Reconciliation of Material Receipts

The material receipt process is often the major cause of ‘missing’ components. (FOSSAC, 1999) Material shipments are received, but due to data exceptions or data error the component is never recorded as received by NAVSUP/NAVICP. The naval supply pipeline is thus left with requisitions that are outstanding and require manual input or carcass tracking to complete.

Carcass (broken repairables) tracking has become a major concern with the Navy logistics community. (Hayes and Mullins, 2002; GAO 02-452, 2002; GAO 96-156, 1999) With component costs rising, the need to maintain control over the Navy’s inventory assets becomes ever more important. Most of the material receipt and carcass tracking efforts involve personnel who reconcile receipts, review receipt and transportation documentation, and use government resources to find missing material.

The basic requisition and follow up process follows this structure:

- Unit sends requisition to NAVSUP/NAVICP logistics system
- Supply in transit (SIT) (requested material shipped)
- Material not reported as received after 45 days, follow up generated by NAVSUP/NAVICP
- Unit responds to follow up (if no response then a second follow up is sent) by either acknowledging receipt or providing information concerning non-receipt
- Depending on the response, additional carcass tracking may occur at unit, depot, and NAVSUP/NAVICP levels. (NAVSUP P-485, 2002)

The system also handles carcasses:

- Unit creates turn-in documentation, sends carcass and documents to O-level repair, transmits turn-in information to ATAC
- O-level determines repair needs, completes repairs or forwards to appropriate repair level, reports receipt and further actions to ATAC and OOMA AISs.
- Material in transit (MIT), follow-up is generated for material not reported as received after 45 days.
- Component repair is completed (or disposed of), part identified as RFI and placed into Navy stock system.

Much of the system is automated; follow ups are sent out automatically if SIT or MIT assets are not reported as received, but manpower is still required to receive, research, and respond to follow up requests.

SNT (and its AIT) could reduce the amount of time that is expended on the reconciliation of receipts. AIT can not only facilitate accurate tracking of material as it proceeds through the logistics pipeline, but can also provide a database that allows multiple users to track components. Thus 'local expertise' becomes less of an issue, and large numbers of dedicated tracking and reconciliation personnel are not needed.

This is an area of concern because during FY2001 33,000, and up to the third quarter of FY2002 over 110,300, follow-ups were generated for Naval Aviation repairables (Appropriations Purchases Account (APA) and Navy Working Capital Fund (NWCF). The large increase in the number of follow-ups was due primarily to the increase in supply activity in support of operation Enduring Freedom. (Supply in transit, 2002)

4. Cost Savings Associated with AIT

The potential for cost savings associated with the SNT AIT is significant. Improved data accuracy and error reduction, inventory man-hour reduction, and recent component usage data are among the areas where AIT will benefit naval logistics.

a. Improved Data Accuracy

Maintenance systems in use today rely on the manual entry of component data; automated entry of this data would immediately reduce labor hours involved in these efforts.

NAVAIR estimated that the time to read and input component data (e.g. NSN, serial number, CAGE code) was 3 minutes. (Mathis, 2002) Tied to this is an ATA survey that evaluates the manual data entry error rate as one error per every thirty characters, with an average time to correct a data error after the fact of 33 minutes. (Krizner, 2000) AIT could drastically reduce the time it takes to record information, the number of errors entered and the error rate. (Hayes and Mullins, 2002; Naval Air Warfare Center, 2000)

By using this information coupled with the number of transactions conducted and then applying the cost of a man-hour we are able to determine an estimated savings for using SNT AIT over manual entry methods.

b. Inventory Man-Hour Reduction

Information developed through the SNT prototype conducted on HSL-40 identified a reduction in aircraft inventory time from three to four days to three to four hours. (Hayes and Mullins, 2002; Naval Air Warfare Center, 2000) Additionally, NAWC estimated that using an AIT system (SNT), Organizational Aircraft Maintenance (OMA) inventories man-hour requirements would drop from 148681 hours per year to 38808 hours. (Appendix B) The NAWC estimate was based on a complete implementation of AIT, across key naval aircraft types. (Huguley, 2000)

c. Component Usage Data

What parts are being used and how much, what parts require the most maintenance, which repair depots have the shortest cycle times, and ‘where is my part’ are just a few of the issues that item managers and logistic officers deal with on a daily basis.

Component usage data savings are often considered intangible and are described as ‘soft’ savings. Generally associated with cost avoidance and opportunity cost, ‘soft’ savings can be biased depending on the audience.

SNT is a tool; it provides information to aid managers who make decisions regarding reliability and maintainability. Using SNT, managers are better able to identify no-fault components, readiness trends, and condemned parts. Additionally, SNT can be used for configuration management, technical directive compliance, or to provide visibility of warranty information. (FOSSAC, 1999)

While this information may save millions or billions in acquisition, repair or life cycle sustainment costs, they are circumstantial and cannot be relied upon for annual savings figures. In order to substantiate the potential for these savings for this report, a survey was provided to item/project managers listed as SNT participants, asking questions concerning their use of the SNT application as a component management tool. The results of this survey are presented in the next chapter.

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IV. ANALYSIS

A. MATERIAL IN-TRANSIT LOSS

Loss information for FY 2000, 2001, 2002 (through June) aviation specific repairables (NWCF and APA) was collected from the NAVSUP Corporate Information System. (Inventory Loss, 2002) An escalation factor for O&MN purchases (similar to a Consumer Price Index factor, but specifically generated for Navy activities) was applied to these figures from the Naval Center for Cost Analysis (NCCA) (O&MN Purchases, 2002) to base all amounts in FY 2002 dollars. An SNT implementation factor (a percentage of how many aviation components are monitored by SNT during given FY) was also applied (Mullins, 2002). Estimated in-transit write-off loss figures for FY 2003, 2004, and 2005 are based on FY 2002 in-transit loss without SNT/AIT devices Mullins, 2002) and an annual cost increase factor of 12 percent. (GAO 00-23, 2000)

Using FY 2002 as the base line, Table 2 illustrates potential savings if SNT is able to eliminate all in-transit write off loss through the use of AIT. Rarely does a system work at 100 percent effectiveness, so Table 2 conservatively assumes a 62.5 percent effectiveness rate which is the average between the maximum effectiveness and the minimum effectiveness (25 percent) as identified by the SNT program office. (Mullins, 2002)

SNT In-Transit Write-off Loss Savings (62.5% effectiveness) - FY02 Dollars

Element	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Total
AIT System Deployed	**0%**	**2%**	**5%**	**15%**	**40%**	**70%**	
In-transist write off loss							
For Aviation components							
Material Loss	$246,201,149	$158,502,593	$130,000,000	$147,492,800	$170,180,732	$199,903,818	$1,052,281,093
Effectiveness (62.5 percent)	0.625	0.625	0.625	0.625	0.625	0.625	
Total Annual Savings	$0	$1,981,282	$4,062,500	$13,827,450	$42,545,183	$87,457,921	$149,874,336

Table 2. SNT ITWOL Savings

B. REDUCTION IN ADMINISTRATIVE COSTS

The NAVAIR SRC loss (Negative Reconstruction) report for FY 2000, 2001, and 2002 (Matthis, 2002) was used to establish a baseline figure for future fiscal years in FY 2002 dollars. In order to estimate the yearly SRC savings, the baseline was adjusted by the by NCCA FY 02 current year composite for O&MN purchases, (O&MN Purchases, 2002) percent of implementation of SNT each year (Mullins, 2002) and projected cost reduction due to AIT/SNT implementation. (NSWCC, 1998)

SRC Loss (Negative Reconstruction) Savings - FY02 Dollars

Element	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Total
AIT System Deployment	**0%**	**2%**	**5%**	**15%**	**40%**	**70%**	
NSWCC savings factor	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	
(NWCF & APA)							
SRC Loss (Base FY 02)*	$8,764,837	$47,496,931	$32,533,752	$32,180,400	$33,152,248	$34,770,078	$188,898,246
SRC loss (Est FY03,04,05)							
Total Annual Savings	$0	$854,945	$1,464,019	$4,344,354	$11,934,809	$21,905,149	$40,503,276

*Baseline SRC : ((FY00/12 + FY01/12 + F02/10)/3) = $2,647,285 Monthly SRC Loss

Table 3. SRC Loss Savings

C. RECONCILIATION OF MATERIAL RECEIPTS

NAVSUP CIS reports that of the 236,085 SIT requisitions created for aviation material (NWCF & APA) during FY 2001; over 33,063 (~15 percent) required a tracking follow-up. For FY 2002 (through June) the numbers are even higher; 601,950 SIT items with 110,894 (~18 percent) of the assets requiring tracking follow-up. (Inventory Loss, 2002) Since the data for FY 2002 is incomplete, to find the annual SIT number 110,984 is divided by nine (months between October and June) and then multiplied by twelve to estimate annual follow-ups.

According to information from COMNAVAIRPAC Code N4113 (Tumald, 2002), it takes from 30 minutes to several hours for personnel to research receipts and turn-in information once they receive a tracking follow-up. For this analysis both a 30-minute and a two-hour average per investigation were used.

30 Minute research time:

FY 2001: 33063 follow-ups X .5 hours per action

= 16531.5 man hours

FY 2002: 147192 follow-ups X .5 hours per action

= 73596 man hours

2 Hour research time:

FY 2001: 33063 follow-ups X 2 hours per action

= 66126 man hours

FY 2002: 147192 follow-ups X 2 hours per action

= 294384 man hours

Using these man hour savings, an estimate of savings can be generated by factoring in the NCCA escalation indices for military pay (MPN, 2002) to establish FY 2002 as the base year and multiplying it by the average 'cost for a sailor' figure developed by NCCA. (Dye, 1998)

Reconciliation of Material Receipts Savings - FY02 Dollars

Element	FY2001	FY2002	FY2003	FY2004	FY2005	Total
AIT System Deployment	**2%**	**5%**	**15%**	**40%**	**70%**	
30 min savings	16,531.5	73,596.0				
2 hour savings	55,197.0	294,384.0				
Average Man Power Savings**	35,864.3	183,990.0	109,927.1	109,927.1	109,927.1	549,635.63
Sailor labor cost*	80.247	85.143	89.230	92.423	95.564	
Total Annual Savings (Base FY 02)	$57,560	$783,273	$1,471,317	$4,063,904	$7,353,589	$13,729,642

* Weighted average based on paygrade and adjusted for inflation
**FY 03 onward average of FY 01 and 02

Table 4. Reconciliation of Material Receipt Savings

D. COST SAVINGS ASSOCIATED WITH AIT

1. Improved Data Accuracy and Input Speed

To find the savings in input speed, NAVAIR's estimate of three minutes (.05 hours) for manual entry of component data in to current tracking systems (OOMA, ATAC) is applied to SNT system deployment, NCCA cost of sailor estimate and the number of SIT requisitions for FY 2001 and FY2002 to find an average number of man-hours saved. (Assumes carcasses (MIT) shipped through ATAC nodes and hubs to intermediate and depot level repair activities are similar in number (plus or minus five percent) to RFI material shipments (SIT)). Since the data for FY 2002 is incomplete, 601,950 is divided by nine (months between

October and June) and then multiplied by twelve to estimate annual number of transactions.

FY 2001: 236,085 transactions X .05 hours = 11804.25 Man-hours

FY 2002: 802,600 transactions X .05 hours = 40130 Man-hours

Automated Data Entry Man-power Savings - FY02 Dollars

Element	FY2001	FY2002	FY2003	FY2004	FY2005	Total
AIT System Deployment	**2%**	**5%**	**15%**	**40%**	**70%**	
Man Power Savings*	11,804.3	40,130.0	25,967.1	25,967.1	25,967.1	129,835.63
Sailor labor cost**	80.247	85.143	89.230	92.423	95.564	
Total Annual Savings (Base FY 02)	$18,945	$170,839	$347,556	$959,981	$1,737,074	$3,234,395

*FY 03 onward average of FY 01 and 02
** Weighted average based on paygrade and adjusted for inflation

Table 5. SNT Automated Data Entry Man-power Savings

Error rates savings are determined in a similar manner as data entry savings. Using the error rate identified by ATA (Krizner, 2000); one error for every 30 characters (approximate 3.3 percent error rate) and 33 minutes (.55 hours) to correct one error after the fact, the total number of error and man-hours need to correct them can be calculated.

Element	FY2001	FY2002	FY2003	FY2004	FY2005	Total
AIT System Deployment	**2%**	**5%**	**15%**	**40%**	**70%**	
Number of Errors*	7791	26486	17138	17138	17138	
Time correct**	4285	14567	9426	9426	9426	47130
Sailor labor cost***	80.247	85.143	89.230	92.423	95.564	
Total Annual Savings (Base F	$6,877	$62,015	$126,163	$348,473	$630,558	$1,174,086

Error Rate Man-power Savings - FY02 Dollars

*FY SIT X .033 hours
**(Number of errors X .55 hours) FY 03 onward average of FY 01 and 02
*** Weighted average based on paygrade and adjusted for inflation

Table 6. Error Rate Man-power Savings

2. Inventory Man-Hour Savings

The Naval Air Warfare Center's (NAWC) data for Aircraft Inventory Man-hour requirements can be found in Appendix B. This information was formulated assuming full implementation of SNT on key naval aviation weapons platforms (trainer, cargo, and personnel transport aircraft were not included).

Total man-hours for Aircraft Verification Inventory from Appendix B:

- Prior to SNT AIT implementation: 148,681
- Following SNT AIT implementation: 38,808
- Difference: 109,873

Element	FY2001	FY2002	FY2003	FY2004	FY2005	Total
System Deployment	**2%**	**5%**	**15%**	**40%**	**70%**	
Inventory Man hour reduction	109873	109873	109873	109873	109873	549365
Sailor labor cost*	80.247	85.143	89.230	92.423	95.564	
Total Annual Savings (Base FY 02)	$176,340	$467,746	$1,470,592	$4,061,903	$7,349,968	$13,526,549

Verification Inventory Man-power Savings - FY02 Dollars

* Weighted average based on paygrade and adjusted for inflation

Table 7. Verification Inventory Man-power Savings

3. Component Data Usage

Item and project managers were surveyed to learn their perception of SNT and if they believed that it would aid them in making resource decisions. Of the managers surveyed only six responses were received, making analysis of this area difficult. Responses received are documented below in Table 8. Appendix D. presents the complete survey and a summation of the responders answers.

Item/Program Manager Survey Results

Questions	A	Yes (B)	No (C)	D	Other / N/A
What is your position					
What program are you involved with (COG or system)?					
How did you learn of SNT					
Is information on SNT better than what you used before		6	0		
Has SNT helped you identify readiness trends?		4	1		1
How easy was it to identify readiness trends	1	0	0	0	5
Does SNT aid your management of program resouces		1	0		5
Readiness; do you feel it has improved due to SNT		3	0		3
Does SNT help you identify parts that may need reengineering?		5	0		1
Do persons working with you have access to SNT?		4	2		
From your perspective is SNT a 'valued added' system		6	0		
Have you made suggestions to improve SNT?		0	6		

Table 8. Survey Results

Appendix D. presents the entire survey; questions and a summary of the answers received.

E. SNT IMPLEMENTATION AND COMPONENT MARKING COSTS

For the Navy to realize the benefit potential described earlier, it must appropriate the hardware and software, generate technical manuals, establish a web-based application, and develop a training program.

NAVAIR and NAVSUP have combined their efforts, talents, and most importantly budgets in developing SNT and its AIT.

Both of the major commands took on one of the SNT elements. NAVSUP seeing SNT as an extension, or next generation, of its inventory tracking service provided for the establishment of the SNT web-based client/server structure operating system. Since NAVAIR in its role as configuration manager for Navy aircraft and approving authority for component alterations, would be the organization most effected by CMB application, it was a logical step for NAVAIR to fund the CMB application and purchase costs.

1. SNT System Deployment Costs

Funding documentation (Hayes, 2000) breaks down NAVSUP cost (and projected cost) for the SNT system since FY 2000, and is summarized the Table 9.

Project Manager:
Project Name: Serial Number Tracking
APPN/Project Identification Code: 464
Funding Requirement Profile - Business Plan BUCON
7/25/2002 0:00

Line Item	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
Non-headquarters Training	200,000	200,000	200,000	200,000	200,000	200,000
Travel:						
Headquarters	15,000	15,000	15,000	15,000	15,000	15,000
Contractor	10,000	10,000	10,000	10,000	10,000	10,000
Others	5,000	5,000	5,000	5,000	5,000	5,000
Non-Information Technology:						
Equipment Purchases						
Contractor Support						
Information Technology:						
Equipment Purchases	1,000,000	100,000	100,000	100,000	100,000	100,000
Contractor Support	620,000	500,000	500,000	500,000	500,000	500,000
DISA Services						
SW (COTS)	250,000					
SW (Contractor)	200,000	170,000	170,000	170,000	170,000	170,000
(Development/Implementation)	2,700,000					
SW (FMSO)						
SW (Development/Implementation)						
SUP 01 Centralized Reservist						
TOTAL	5,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000

Table 9. SNT Funding Profile

2. Component Marking Costs

CMBs, with their ease of use, adaptability and storage capacity, are the principle improvement of the SNT system over the manual entry and bar code systems in use today.

Of the two parts of the SNT program, component marking is larger and more costly (see Table 10). Although CMB application and procurement should not be defined as a reoccurring cost since CMBs are intended to remain on components for their service life, there will be a need to mark new acquisitions, inventory in warehouses and installed components as they are received or accessed.

NAVAIR has estimated the cost of installing CMBs on aircraft currently in the Navy's inventory. (Wiley, 2002) Appendix C. provides detailed information concerning CMB installation in a Microsoft Excel™ format. The CMB cost data found in Appendix C. is summarized in Table 10.

Cost Elements	
CMB Cost	
Number of Aircraft (USN/USMC)	4,779
Number of Marked Components	4,658
tal Number of CMBs (W/25% spares)	1,267,091
TOTAL Cost of CMB	$19,804,636
Contractor Installation Cost	$29,120,843
Engineering Document Cost	$3,726,400
Misc Support	$2,805,000
TOTAL COMPONENT MARKING COST	$55,456,879

Table 10. CMB Component Marking Costs

F. COST BENEFIT ANALYSIS

Is SNT worth the cost of investment? SNT benefits are based upon predicted savings estimates by informed organizations. It can be assumed, as evidenced through their continued funding of research and program expansion, that NAVSUP, NAVAIR, NSWC Cardirock, and Naval Sea Systems Command (NAVSEA) believe SNT (or some form of it) can provide improved asset and component management.

Table 11 summarizes Tables 2-7, 9, 10 and gives a consolidated picture of the costs and savings that SNT could achieve for Naval Aviation components.

Payback for the system in its present form does not occur until FY 2005, assuming that implementation progresses at a steady rate.

Summary of Costs and Benefits In FY 02 Dollars

Cost Description	2000	2001	2002	2003	2004	2005	Total
Costs of SNT System							
(Table 10) SNT System Cost	5,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	10,000,000
(Table 11) CMB Costs*	0	0	13,864,220	13,864,220	13,864,220	13,864,220	55,456,879
Total Tangible Costs of New System	5,000,000	1,000,000	14,864,220	14,864,220	14,864,220	14,864,220	65,456,879
Benefits							
(Table 3) Loss In-transit Savings	0	1,981,282	4,062,500	13,827,450	42,545,183	87,457,921	149,874,336
(Table 4) SRC Card Loss Savings	0	854,945	1,464,019	4,344,354	11,934,809	21,905,149	40,503,276
(Table 5) Receipt Reconciliation Savings	0	57,560	783,273	1,471,317	4,063,904	7,353,589	13,729,642
(Table 6) Automation Savings	0	18,945	170,839	347,556	959,981	1,737,074	3,234,395
(Table 7) Error Savings	0	6,877	62,015	126,163	348,473	630,558	1,174,086
(Table 8) Inventory Verification Savings	0	176,340	467,746	1,470,592	4,061,903	7,349,968	13,526,549
Cumulative Benefits	0	3,095,950	7,010,391	21,587,432	63,914,253	126,434,258	222,042,284
Net Benefits (Or Loss)	-5,000,000	2,095,950	-7,853,829	6,723,212	49,050,033	111,570,038	156,585,405
Payback (In whole years)						1.00	
Rate of Return on Investment	29.48%						

*** For worksheet; CMB cost spread over FY 2002-2005**

Table 11. Summary of SNT Costs and Benefits

G. SUMMARY

The analysis presented in this chapter is based on information from a variety of sources, some of which are in a continual state of change. Of the variables, technology is one of the most fluid; costs associated with it may rise or fall, even while the application of technology finds new uses. Since technology, or at least its application, is at the heart of the SNT AIT system, awareness of current trends is important to overall SNT cost.

For the operational side of SNT, we anticipate that implementation schedule changes, actual SRC loss, loss in transit write off, and the numbers of SIT requisitions and MIT turn-ins can (and will) significantly change the level of monetary benefits SNT can provide.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. The SNT Program Could Save the Navy Over 60 Percent of the Costs Associated with ‘Lost-In-Transit Write Off’ Components.

Based on the discussion and analysis in Chapters III and IV, a conservative ‘loss in transit’ savings factor of 62.5 percent is an achievable goal. If this savings factor is applied to the GAO report that identified $3 billion in Navy loss in-transit write off between FY 1996 and FY 1998 (GAO 99-61, 1999), then the savings, or cost avoidance, could be estimated at nearly 2 billion dollars. This example simplifies a complex problem, however any system that provides a nearly two-thirds reduction in expenditures merits consideration.

2. AIT Solutions are Only as Good as Their Implementation

Much of the success of SNT relies on the widespread implementation of the program. The discussion and analysis in Chapter IV demonstrates that as implementation increased and spread to additional aviation platforms and components, the savings generated by the SNT program rose proportionally. However, as of August 2002, SNT implementation is estimated to be at less than six percent, nearly ten percent lower than originally planned (Mullins, 2002). At this pace, program costs could keep SNT from ‘breaking even’ until after FY 2006.

3. SNT Relies too Much on Legacy AIS

Legacy AIS systems form the backbone of SNT. As these systems age and technology advances, technology specialists lose the ability to go back into older systems to fix or modify their interfaces, data or code. Although most of the aging systems associated with SNT have been reliable, how much longer will they be supportable in an environment where system support costs increase because of the lack of personnel with "vintage" knowledge. The complexities of developing a new standalone SNT system are immense; the need for SNT to interface more than eight databases reflects this and yet building such a system may prove to be more effective in the long run.

4. CMBs are Currently the Best Choice AIT

As the research shows, CMBs are highly effective and will provide the aviation community a method to efficiently monitor and track its NWCF and APA components. Even as the use of CMBs increase, their capacity for maintenance file storage is not being exploited and therefore their full potential is not being realized. CMBs can provide maintainers with the ability to put permanent maintenance records on nearly all significant components, records that cannot be lost or easily destroyed. Of the other AIT media, none currently available provide the level of memory storage, flexibility and durability that can be found in CMBs.

5. Alternatives to SNT

SNT was developed as a 'stepping stone' for ERP systems, as a system that consolidates information from several sources allowing managers to access what data they need when they need it. Here are the alternatives to SNT:

a. Do Nothing

To do nothing is a choice. Navy legacy systems have been tracking parts and requisitions for nearly 20 years; despite their problems they still functioned well enough to handle over a billion requisitions during FY 2002. But not well enough, in-transit losses, SRC losses and material receipt follow-up requirements call for a new system to track components.

b. Replace with a COTS System

Since the initial serial number tracking research conducted in 1998, there have been improvements in automated information systems, especially in the realm of ERP. Throughout DoD, commercial ERP systems are being tested and implemented in an effort to improve the data accessibility of our legacy systems. However, SNT as been developed as a unique system whose abilities cannot be easily duplicated by a COTS system.

c. Change AIT Media

As identified in Chapter II, there are three other AIT media that could be used with SNT: (1) RFID paper transponders, (2) Optical Memory Cards and (3) 2D Maxicode bar codes. Each has its advantages and disadvantages when compared to CMBs (see Appendix A.), but none at this time provide the memory size, flexibility or durability of CMBs.

B. RECOMMENDATIONS

1. NAVSUP Should Press Implementation of SNT

The SNT system should be implemented Navy-wide. NAVSUP must be the driving force behind that implementation. Although prototyping and research is progressing outside of the aviation community, the potential two-thirds savings from SNT can only be realized if the system is in place and operating. Therefore, it makes sense to employ the system on as many platforms and components as possible. But, the SNT system is presently only scheduled for full implementation within the aviation community, with Fleet-wide implementation happening "at a later date". (Commander NAVSUP, 2001) The aviation, submarine, and surface combatant communities each have high cost components, and NAVSUP manages many of those components, a program that can significantly benefit one should be extended to all.

2. Additional Resources Should be Earmarked for SNT

While SNT may not be the "silver bullet" solution to the Navy's lost material problems, it has the potential to reduce these loses. Underfunding or ignoring this program would be a mistake that would not be in the best interests of DoD. More importantly, expanding SNT resources may speed implementation Navy-wide.

3. The Uses of SNT in Component Configuration Should be Expanded

SNT has the potential to impact many of the components that require modernization or reengineering due to aging or poor design. SNT can capture the data needed to evaluate a component for reengineering. Trend reports on maintenance actions presently include reports on; Highest Failure, Beyond Capability Maintenance (BCM), No-Fault Found (NFF)(i.e. rouge) and Highest Cannibalization, all of which are available online at the SNT web-site. This information, properly monitored and evaluated, could generate benefits beyond the simple tracking of components.

A separate organization, or NAVSUP code, should be detailed to monitor these reports and use them to enhance the effectiveness of aircraft program officers and item managers.

C. ADDITIONAL AREAS OF RESEARCH

This study has only begun to explore the value of SNT. It is the author's intention that this work may encourage others to examine the benefits of SNT and other AIT systems.

SNT is continuing to grow and with that growth may expand into areas not reviewed by the body of this work. Areas for future research include;

- CMB advancement and utilization
- SNT interface with SIMGA
- SNT use as a configuration tool
- Use of CMBs and SNT as Maintenance logs
- Fleet-wide implementation of SNT

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APPENDIX A. AIT MEDIUM COMPARISON

AIT Mediums	Applications	Capacity	Capability	Adopted By
		Characters = CHAR, Numbers = NUM	*Dynamic Data File = DDF*	*Automative Industry Group = AIAG*
			User tag ID = UID	*Material Handling Assciation = MHA*
Linear Bar Code (Standards)				
Code 39	Supply, Personnel, Transportation, Maintenance	20 Char	43 Char, 26 letters, 10 Num, 6 symbols	DoD, AIAG, Health Industry Bar Code Council
Code 128	Supply, Transportation, Maintenance	64 Char for verifier, 128 Char	ASCII 128 Char, 4 non-data function Char	ATA, Electronics Industry Association, MHA, AIAG
Codabar	Blood banks, Libraries, Preprinted air bills	6 Char	10 Num	Medical community
Inter-leaved 2 of 5	Markings for shipping containers & air baggage	6 Char	10 Num	ATA (baggage) Uniform Code Council (container)
2D Bar Code (Standards)				
PDF 417	Supply, Personnel, Transportation, Maintenance	1850 Nums, 950 Char (DoD lvl 5 security)	ASC II 128 Char, 4 non-data function Char	DoD Military shipping label, Military ID card
Data Matrix	Direct Marketing	3116 Num, 2335 Char	2D scanable - requires CCD scanner	UPS
Maxicode	Rapid Sorting	256 Char	2D scanable - requires CCD scanner	Electronics Industry
Micro PDF	Supply, Personnel, Transportation, Maintenance	64 Char	scanable	Telecommunication Industry, MHA
UCC/EAN Composite	Supply, Personnel, Transportation, Maintenance	2D - 2.4K digits, Linear - 48 digits	PDF and linear composite scanable	International standard
Aztec	Direct Marketing	1914 bytes	2D scanable	Commercial tracking
QR Code	Ultra high speed sorting	7K numeric and 4K alpha	40 types, application specific	For high speed processing
Magnetic Stripe	Personal, Financial, Security, Identifcation card	490 bits	Read/write capability DDF	DoD, Credit card companies
Smart Card	Personnel, Financial, Transportation, Maintenance	32 KB to 1MB uncompressed	Read/write capability DDF	DoD, Credit card companies
	Physical Security, Infosec, Identification card			
OMC, Laser card	Supply, Personnel, Transportation, Maintenance	2.4 MB manufacturer defined	WORM, re-write	DELA, DoD
RFID				
Active	Supply, Transportation, Maintenance	2KB to 128 K	Read/write, DDF, 300' range, UID	DoD
Electronic Article Surveillance (EAS)	Retail Security - alert notification	1 bit on/off	Read only, Can be programmed by user	Commercial vendors
SAW	Secure Acoustic Wave	4 to 16 bits	Read only, Programmed by manufacturer	Commercial retailers
Inductive	Retail, Access control	32 bits to 2 bytes	Read only, Programmed by manufacturer	Commercial vendors
Modulated Backscatter	Toll systems	32 bits to 2 bytes	Read/write, DDF, 300' range, UID	Commercial vendors
Active/ modulated Backscatter	Toll systems, Remote data call	32 bits to 2 bytes	Read/write, DDF, 4" to 15' range, UID	Rail transportation
RFCD, Active	Retail and warehousing	Dependant on AIS and AIT Medium	500' to 1 ½ miles	None, mainly manufacturers proprietary systems
Biometrics	Personnel, Financial, Physical Security, Infosec	Application specific	8 types, application specific	DoD, Security industry
	Personal Identification			
Contact Memory	Supply, Personnel, Transportation, Maintenance	32KB uncompressed, to 4 MB compressed	Read/write, encryptable	Fleet maintenance, oil companies, food producers, speed

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APPENDIX B. NAVAL AIRCRAFT VERIFICATION INVENTORY MAN-HOUR REDUCTION WORKSHEET

Aircraft Inventory Man-Hour Worksheet

Platform	# of aircraft per squadron	Number of Squadrons	Serial Number Verification Interval	Average # of Verifications per year per aircraft	Hours per Verification	# of Assigned Personnel	Total man hours expended on Serial Number Verifications per year per squadron	Total man hours/platform /year	Hours per verification with AIT	Total man hours expended on Serial Number Verifications per year per squadron with AIT	Total man hours/platform/year w/AIT
H-60	10	40	150 flight hours	3	16	2	960	38400	4	240	9600
E-2C	5	14	250 flight hours	3	2	12	360	5040	1	90	1260
E-6B	8	2	600 flight hours	2	4	7	448	896	1	112	224
P-3	9	33	300 flight hours	2	8	6	864	28512	2	216	7128
H-53	16	20	150 flight hours	2	12	2	768	15360	3	192	3840
F/A-18	12	40	150 flight hours	2	14	2	672	26880	4	168	6720
S-3B	9	13	150 flight hours	3	4.5	7	850.5	11057	1	213	2764
F-14	12	16	200 flight hours	3	2.5	6	540	8640	1	216	3456
EA-6B	4	19	150 flight hours	3	3	6	216	4104	1	72	1368
H-46	12	17	100 flight hours	3	8	2	576	9792	2	144	2448
				Total Serial Number Verification Man Hours				148681			38808

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APPENDIX C. NAVAIR CMB PURCHASE AND IMPLENENTATION COST

Type/Model/ Series	Total Number Aircraft	Components per Aircraft	Total Number of Components (W/25 % spares)	Total CMB Cost	Contractor Installation Cost	Total Engineering Document Cost	
MH-53E	46	170	9,775	$152,783.25	$272,412.00	$136,000.00	$561,195.25
CH-53E	164	170	34,850	$544,705.50	$817,236.00	$136,000.00	$1,497,941.50
CH-53D	44	104	5,720	$89,403.60	$272,412.00	$83,200.00	$445,015.60
All H-60	342	300	128,250	$2,004,547.50	$3,268,944.00	$240,000.00	$5,513,491.50
S-3B	111	400	55,500	$867,465.00	$708,271.20	$320,000.00	$1,895,736.20
E6A/B	16	469	9,380	$146,609.40	$163,447.20	$375,200.00	$685,256.60
AH-1W	194	196	47,530	$742,893.90	$898,959.60	$156,800.00	$1,798,653.50
HH/UH-1N	126	132	20,790	$324,947.70	$599,306.40	$105,600.00	$1,029,854.10
CH-46E	230	70	20,125	$314,553.75	$926,200.80	$56,000.00	$1,296,754.55
CH/HH/UH-46D	79	70	6,913	$108,042.38	$435,859.20	$56,000.00	$599,901.58
EA-6B	124	144	22,320	$348,861.60	$1,035,165.60	$115,200.00	$1,499,227.20
MV/CV/HV-22	458	203	116,218	$1,816,479.53	$3,922,732.80	$162,400.00	$5,901,612.33
AV-8	172	921	198,015	$3,094,974.45	$871,718.40	$736,800.00	$4,703,492.85
F-14A/B/D	193	200	48,250	$754,147.50	$871,718.40	$160,000.00	$1,785,865.90
P-3's	264	75	24,750	$386,842.50	$1,797,919.20	$60,000.00	$2,244,761.70
Cargo	295	175	64,531	$1,008,623.44	$2,724,120.00	$140,000.00	$3,872,743.44
Trainers	515	129	83,044	$1,297,973.81	$817,236.00	$103,200.00	$2,218,409.81
E-2C	75	145	13,594	$212,470.31	$1,525,507.20	$116,000.00	$1,853,977.51
C-2A	38	145	6,888	$107,651.63	$217,929.60	$116,000.00	$441,581.23
F-18ABCD	745	200	186,250	$2,911,087.50	$4,794,451.20	$160,000.00	$7,865,538.70
F-18EF	548	240	164,400	$2,569,572.00	$2,179,296.00	$192,000.00	$4,940,868.00
Misc Support							$2,805,000.00
Total	4779		1,267,091	$19,804,636.24	$29,120,842.80	$3,726,400.00	$55,456,879.05

NAVAIR CMB PURCHASE AND INSTALLATION COSTS

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APPENDIX D. SNT USER SURVEY AND SUMMARY OF ANSWERS

1. SNT SURVEY

A. What is your position?
- a. Item Manager
- b. Program Manager
- c. Other ____________________

B. What program/items are you involved with? (system name and/or COG)
- a. ______________

C. How did you learn of SNT?
- a. Command brief
- b. External brief (outside organization (e.g. SNT office) provided brief)
- c. Given handbook
- d. Other ____________________

D. Do you have a SNT account (login)
- a. Yes
- b. No (if no skip to question K)

E. Is the information on SNT better than what you used before
- a. Yes
- b. No

F. Has SNT access given you the ability to identify readiness trends (i.e. rouge parts, bad performers, slow repair cycles)
- a. Yes
- b. No
- c. (Optional: Explain)

G. How easy is it to identify readiness trends on SNT?
- a. Very easy
- b. Easy
- c. Not easy
- d. I use another method

H. Does SNT aid in your management of components and program funding (i.e. based on trends have you been able shift resources to improve support of problem components)
- a. Yes
- b. No

c. (Optional: Explain)

I. Readiness; do you feel that it has improved (or will improve) due to SNT?
   a. Yes
   b. No
   c. (Optional: Explain)

J. If SNT showed that a component/part operates below engineered failure rates (fails every 300 hours vise every 3000 hours) is there a method available to you (either directly or by presentation to higher authority) to research reengineering the part?
   a. Yes
   b. No
   c. (Optional: Explain)

K. Do persons working for/with you have SNT access?
   a. Yes
   b. No

L. From your perspective is SNT a 'value added' system?
   a. Yes
   b. No
   c. (Optional: Explain)

M. Have you made suggestions to improve SNT; have the SNT designers acted on your suggestions?
   a. Yes, Yes
   b. Yes, No
   c. No

N. Any questions I should have asked?

2. SURVEY RESULTS

A. What is your position?

- Supply Systems Analyst
- Industrial Support Technician
- Logs and Records keeper
- Item Manager
- Logistics Systems Analyst

B. What program(s) are you involved with?

- Depot Repair Schedules, all aviation components (2)
- Performance Based Logistics (PBL) contract (multiple items) (2)
- E-2, C-2, H-53
- EA-6B

C. How did you learn of SNT

- Web search
- External Organization Conducted training (Class) (4)
- Government Contractor

D-L. Summary on Table below.

Item/Program Manager Survey Results

Questions	A	Yes (B)	No (C)	D	N/A
Is information on SNT better than what you used before		6	0		
Has SNT helped you identify readiness trends?		4	1		1
How easy was it to identify readiness trends	1	0	0	0	5
Does SNT aid your management of program resouces		1	0		5
Readiness; do you feel it has improved due to SNT		3	0		3
Does SNT help you identify parts that may need reengineering?		5	0		1
Do persons working with you have access to SNT?		4	2		
From your perspective is SNT a 'valued added' system		6	0		
Have you made suggestions to improve SNT?		0	6		

APPENDIX E. LIST OF ACRONYMS

AD	Aircraft Division
AIM	Automatic Identification Manufactures
AIS	Automated Information System
AIT	Automatic Identification Technology
APA	Appropriations Purchases Account
ATA	Air Transportation Association
ATAC	Advanced Traceability and Control
AVDLR	Aviation Depot Level Repairable
BCA	Business Case Analysis
BPI	Bits per inch
CAC	Common Access Card
CAGE	Commercial And Government Entity
CCD	Change Coupled Device
CD	Compact Disc
CIS	Corporate Information System
CMB	Contact Memory Button
COMNAVAIRPAC	Commander Naval Air Forces Pacific
CONOPS	Concept of Operations
COTS	Commercial Off The Shelf
DeMIL	Demilitarization
DoD	Department of Defense
ERP	Enterprise Resource Planning

FOSSAC	Fitting Out and Supply Support Assistance Center
FY	Fiscal Year
GAO	Government Accounting Office
GTN	Global Transportation Network
HAZMAT	Hazardous Material
HF	High Frequency
HSLWINGLANT	Helicopter Anti Submarine Wing Light, Atlantic
HSL-40	Helicopter Anti Submarine Squadron Light Forty
ICC	Integrated Circuit Chip
ILS	Integrated Logistics Support
IT	Information Technology
JTAV	Joint Total Asset Visibility
KB	Kilo bytes
LED	Light Emitting Diode
MB	Mega byte
MIT	Material In Transit
MRPII	Manufacturing Resource Planning II
NALCOMIS OOMA	Navy Aviation Maintenance System; Optimized Organizational Maintenance Activities
NAVAIR	Naval Air Systems Command
NAVICP	Naval Inventory Control Point
NAVSUP	Naval Supply Systems Command

NAWC	Naval Air Warfare Center
NCCA	Naval Center for Cost Analysis
NRFI	Not Ready For Issue
NSN	National Stock Number
NWCF	Navy Working Capital Fund
OMC	Optical Memory Card
RF	Radio Frequency
RFDC	Radio Frequency Data Collection
RFI	Ready For Issue
RFID	Radio Frequency Identification
RITV	Regional In Transit Visibility
SIT	Supply In Transit
SMART	Supply Maintenance Aviation Reengineering Team
SMIC	Special Material Identification Code
SNT	Serial Number Tracking
SRC	Scheduled Removal Card
TAV	Total Asset Visibility
TCN	Transportation Control Numbers
VLD	Visible Laser Diodes
VSDW	Virtual Shared Data Warehouse

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